

**First Implementation and Status Report
Lake Okeechobee
Phosphorus Source Control Grant Program Project
At McArthur Farms Barn # 3**

**QED Occtech
Tangential Flow Wastewater Treatment System
Okeechobee, Florida**

June 2004

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1 SUMMARY

The QTFS at McArthur farms has now been operational for over 6 months and has provided many operational insights into Florida Dairy practices. During this period many operational challenges have been overcome in order to achieve regular system operation. The major operational challenges that have been overcome include sand entering the system, frequent (daily) electrical surges and power failures, lightning strikes, flow surges and irregular solids contents (thus leading to solids overloading), and the relocation of the auto-samplers to more accurately reflect sample raw and treated wastewater.

Based on some innovative fixes to the issues identified above, the system is now consistently operational. This in turn, will allow auto-sampler results to accurately reflect P-removal rates. Thus the focus can now shift towards acceptable P-removal and the economics of the P-removal.

The biosolids from the McArthur QTFS show clear analytical evidence that the P is being concentrated in the sludge from the QTFS system. In addition, the biomass is now contracted for removal from the farm site by a composting company ensuring the export of P and N from the Okeechobee basin.

2 PROJECT BACKGROUND

In mid 2002, QED Occtech, with support from South Florida Water Management District (SFWMD) and the Florida Department of Agriculture and Consumer Services (FDACS), agreed to install a specialized wastewater treatment system (WWTS) at McArthur Farms No 3 Dairy to treat a portion (approximately 50%) of the wastewater produced from a 1600 head milking operation.

The purpose of installing the WWTS was to demonstrate its ability to reduce the level of phosphorous (P) in the represented waste water stream, thus providing the opportunity to recycle the water and reduce the P loading to the lagoon system.

The plant consists of a number of discrete operations, which reduce the P in the treated water, such that the water is suitable for recycling, and produces a solid nutrient-rich waste product for feed stock for anaerobic digestion, compost, fertilizer, gasification or bio diesel. The plant was commissioned in October 2003 and has been in continuous operation treating a large portion of available waste produced by the dairy farm.

The basic configuration of the wastewater treatment system at McArthur is as follows:

1. Coarse Screening – to remove coarse solid and a small proportion of the P
2. Sand Separator – to remove the sand
3. QTFS – to remove the fine solids and the bulk of the P
4. Dewatering bins – to produce minimum 15% solids to be commingled with the screened solids.

3 SYSTEM OPTIMIZATION: OCTOBER 2003 – MAY 2004

Since commissioning the system in October 2003, operations have been optimized to increase simplicity, effectiveness and flexibility.

The increase in volume and timing of volume to the sand trap resulted in poor sand trap performance and subsequently sand contamination of the QTFS system. The resultant frequent plant shut downs invalidated the auto-sampler averaged results. It appears that



even a minor shutdown for a few hours sufficiently contaminates samples to make results unrepresentative. The causes of the increases and variation in the flows have been identified and measures implemented to improve the balance throughout the system. The operation of the sand trap has been reviewed and corrective measures taken to assure more efficient sand removal.

A major initiative by QED to provide additional operator training has been vital in refining the way they operate the plant. Formal classroom sessions were undertaken in February 2004 and feedback from the operators has displayed a high level of competency.

The operational feedback from the first six months has pinpointed the specific actions needed for improving the overall efficiency of the entire system (from the management of the barns to the discharge of treated waste water) for future periods.

As of mid-April 2004 the plant was operating 24 hours a day, seven days a week basis and all major plant optimization issues have been completed. The plant operated without chemical supplementation for the period mid-April to 1 May.

4 WATER TREATMENT RESULTS

During commissioning, spot sample analysis undertaken by QED Occtech indicated that the plant was capable of removing 80% of phosphorous from the wastewater. Recent work undertaken, with a chemical supplier and under observation of the FDACS have reiterated these results and even demonstrated 90% P removal is achievable) and recent results have also backed this capability. It was also confirmed during commissioning that for this waste stream the amount of phosphorous removed strongly correlated to the amount of ferric sulfate added and that small changes to the amount of ferric sulfate added could have large impacts on P-removal.

However, during the first five months of operations the auto-sampler results were taken during a period where the system had numerous weekly stoppages. As a consequence, the results do not accurately reflect P-removal rates. The problems were addressed and operations normalized in April/May 2004. For a two week period beginning April 29th the system was run without chemical additions. The results from the auto-samplers for April are as follows:

The sampling locations are as follows:

- | | | |
|-----------------------|---|--|
| Sand Separator | - | taken in the first entrance to the sand separator, and is post screening |
| Before Screen | - | this is prescreened wastewater |
| After Screen | - | this is coarse screened wastewater |
| Auto sampler 1 | - | sampled from the raw wastewater tank* |
| Auto sampler 2 | - | sampled from the treated wastewater tank** |
| QED Press | - | treated wastewater that flows from the dewatered sludge |



Table 1. Analytical results from QTFS from period of operational continuous running and with low ppm (~100ppm) ferric dosing or no chemical dosing.

Date	Sand Separator	Before Screen	After Screen	Auto Sampler 1	Auto Sampler 2	%TP reduction
*04/08/04	ns	ns	ns	76.4	43	44
*04/15/04	ns	ns	ns	77.5	46.8	37
*04/23/04	ns	ns	ns	104	63.8	39
**04/29/04	61.8	76	71	68.7	54.4	21

* limited chemical application ~100ppm ferric sulfate dosing.

** no chemistry addition

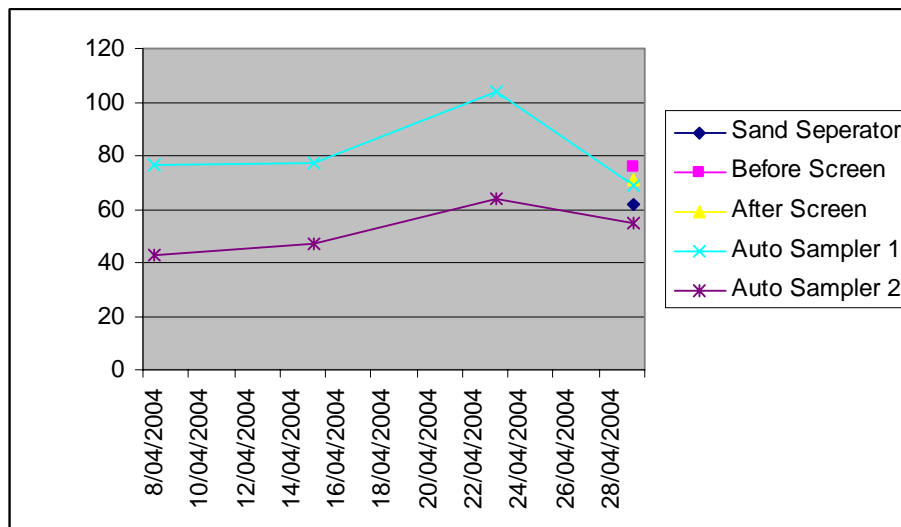


Figure 1. Graphical depiction of Table 1 results. Long axis is months, short axis is ppm (mg/l).

There are several important points to note from the data:

- The average P removal with limited (< 500ppm) ferric addition is 40%.
- When the average P of the raw increases, the rate of P removal stays the same. This indicates P-removal is likely proportional to ferric dosage rate, thus supporting the findings found during commissioning when the system achieved an 80% P removal.
- The average P removal with no chemical addition is 20%

With the implementation of corrective operational actions needed to eliminate the flow variation and volume and more stringent operational safeguards, the next 3 months of operations have provided much more robust data on QTFS P-removal rates and overall wastewater treatment strategy.

The raw results from the data presented in Figure 1 are attached in Appendix 1.



5 DEWATERED SOLIDS

The analytical data for the various solid waste streams from the barns are presented in Attachment 1 and the raw results detailed in Appendices 2a-c. The results can be summarized as follows:

Table 2. Composition of solids waste streams.

Solid Source	% Solids	P content
Raw Wastewater	<1%	77ppm average
Run Down Screens	15 – 27% solids	252ppm average
Solids scraped from barn floor	5-15% solids	350-1138ppm
Run Down Screen Solids	15-27% solids	252ppm average
QTFS	7-13% solids	1153ppm average, ranges from 538 to 2344ppm

From the analytical data it can be clearly observed that P is being concentrated in the sludge from the QTFS system. Hence these solids make excellent ingredient for compost in addition with the more nutrient poor screened solids. During the next three months of continuous operation, a mass balance of solids and P will be established.

In recent months McArthur has reached an agreement with a major compost company that supplies Palm Beach County and Orange County with composts. As a result all solids from the Barn 3 WWTS are now taken off site and out of the Okeechobee Basin.

6 OPERATING COSTS

The operating cost of the WWTS can be segregated into 3 distinct categories, namely:

- operating labour,
- reagents, and
- monitoring and reporting.

Two of the three operating costs are essentially independent of level of nutrients removed, where as the chemical consumption cost is directly related to the quantity of nutrients removed.

The QTFS operating costs have not been determined during this first six month period because of the operational inconsistencies and the ongoing polymer trails. However, the following costs have been documented:

Chemical reagent - treatment costs, during this time period, for QTFS per 1000 gallons have ranged between \$0.10 to \$0.60. Variations have been experimented with to



determine optimum flocculation rates. Currently the dosing rates are at 5 ppm for the polymer and average of 400 ppm dose rate for the ferric. Considerably more precise chemical dose rates and economics will be evaluated over the next 3-6 month period.

Electricity –The system has been modified since installation to accommodate for sand entering the system. The power usage is now is at approximately \$800 per month. These costs are expected to drop further as the system is further optimized.

O&M operation – The average man hours now spent at the QTFS system is three hours per day, based on \$25.00 per hour this equates to \$0.47 per thousand gallons treated. These costs are high do to the nature of the dewatering process. As a result we are actively looking at changing the system to utilise the screw press for dewatering, thus eliminating the need for the operator to manually operate the dewatering process.

Dewatering - Dewatering reagent costs (multiple technology options): currently the container dewatering system utilizes approximately 300 ppm polymer dose rate for the sludge received. This is on the order of twice the expected dosing rate for this type of dewatering system, and hence is under intense scrutiny to find the appropriate polymer for dewatering. As a result the dose rates and costs will change within the next reporting period and will be set out with considerable more accuracy.

7 CONCLUSION

The first six months of operations at McArthur have provided many operational insights into wastewater management at dairies in the Okeechobee Basin. There have been numerous changes to the waste water treatment plant in order to ensure consistent operations. The system has within the first six month period not achieved efficient P removal of wastewater due primarily to inconsistent feed and resultant issues with plant operation. As a result of more normalized operations achieved at the end of the first six month period, the process of focusing on the economics of efficient phosphorus removal from a large-scale dairy wastewater stream is now underway.

Over the next three months development will be undertaken to demonstrate the flexibility of the QTFS technology for continued removal of nutrient and solids from wastewater flows, but using alternative flocculant remedies.

The biomass from the McArthur QTFS shows clear analytical evidence that the P is being concentrated in the sludge from the QTFS system. In addition, the biomass is now contracted for removal from the farm site by a composting company ensuring the export of P and N from the Okeechobee basin.



ATTACHMENT 1. Solids analysis table as received from FDACS (refer to Attachment 2 for raw data).

More detail given in Appendix 2a-c, Data labelled “Scraped floor” or “Raw” is solids directly off the CAFO barn floor, “QED Sludge” is the sludge out of the dewatering bins, “McArthur Screened material” are the solids from the run down screens), and “Grit Chamber” is the screening prior to entry into the QTFS.

Key

TS = total Solids
TA = Total Ash
TN = Total Nitrogen
P = Total Elemental Phosphorus
K = Total Elemental K
H2O = Moisture
EAN = Estimated Available Nitrogen

McArthur Solids Sampling									
DATE	Results	Raw	MCA Screen			QED Sludge		Grit Chamber	
7/08/2003	TS	140.1 ppt							
	TA	31.9 ppt							
	TN	3.9 ppt							
	P	1.138 ppt							
	K	967 ppm							
	H2O	86.00%							
	pH	6.5							
	Avail N	2.8#/ton							
40#/A	P Rate	7.7 T/A							
160#/A	N Rate	57.0 T/A							
21/08/2003	TS	123.4 ppt							
	TA	18.1 ppt							
	TN	3.85 ppt							
	P	350 ppm							
	K	975 ppm							
	H2O	87.70%							
	pH	6.5							



	Avail N	2.7 #/T							
40#/A	P Rate	9.0 T/A							
160#/A	N Rate	58.3 T/A							
4/09/2003	TS	123.5 ppt							
	TA	14.7 ppt							
	TN	4.1 ppt							
	P	894 ppm							
	K	890 ppm							
	H2O	87.70%							
	pH	6.4							
	Avail N	2.9 #/T							

DATE	Results	Raw	MCA Screen			QED Sludge		Grit Chamber	
40#/A	P Rate	9.8 T/A							
160#/A	N Rate	54.6 T/A							
18/09/2003	TS	133.5 ppt							
	TA	20.5 ppt							
	TN	4.2 ppt							
	P	1,138 ppm							
	K	778 ppm							
	H2O	86.70%							
	pH	6.9							
	Avail N	3.0#/T							
40#/A	P Rate	7.7 T/A							
160#/A	N Rate	53.5 T/A							
2/10/2003	TS	157.7 ppt							
	TA	28.9 ppt							
	TN	5.3 ppt							
	P	1,063 ppm							
	K	1288 ppm							
	H2O	84.20%							
	pH	7							
	Avail N	3.8 #/T							



40#/A	P Rate	8.3 T/A							
160#/A	N Rate	42.1 T/A							
16/10/2003	TS	131.7 ppt							
	TA	15.7 ppt							
	TN	3.5 ppt							
	P	931 ppm							
	K	974 ppm							
	H2O	86.80%							
	pH	6.9							
	Avail N	2.5 #/T							
40#/A	P Rate	9.5 T/A							



DATE	Results	Raw	MCA Screen			QED Sludge		Grit Chamber	
160#/A	N Rate	64.2 T/A							
30/10/2003	TS	43.7 ppt	194.2 ppt			91.6 ppt			
	TA	18.8 ppt	36.9 ppt			23.2 ppt			
	TN	3.9 ppt	2.0 ppt			4.5 ppt			
	P	1,100 ppm	288 ppm			2,344 ppm			
	K	1,090 ppm	539 ppm			593 ppm			
	H2O	95.60%	80.10%			90.80%			
	pH	7	7.9			7.6			
	Avail N	2.8#/T	1.4#/T			3.2#/T			
40#/A	P Rate	8 T/A	40 T/A			7.3 T/A			
160#/A	N Rate	53.3 T/A	160 T/A			53.3 T/A			
24/11/2003	TS	130.1 ppt	155.1 ppt			65.0 ppt			
	TA	18.3 ppt	41.1 ppt			11.5 ppt			
	TN	4.8 ppt	1.4 ppt			2.4 ppt			
	P	1,313 ppm	231 ppm			538 ppm			
	K	954 ppm	469 ppm			413 ppm			
	H2O	87.00%	84.50%			93.40%			
	pH	6.4	8			6.4			
	Avail N	6.9 #/T	2.0#/T			1.7#/T			
40#/A	P Rate	6.7 T/A	40 T/A			20 T/A			
160#/A	N Rate	22.9 T/A	80 T/A			80 T/A			
23/12/2003	TS	122.7 ppt	212.6 ppt			136.0 ppt			
	TA	13.6 ppt	47.6 ppt			16.3 ppt			
	TN	3.0 ppt	2.275 ppt			3.7 ppt			
	P	681 ppm	250 ppm			731 ppm			
	K	765 ppm	585 ppm			666 ppm			
	H2O	87.70%	78.40%			86.40%			
	pH	6.6	8.6			7.8			
	Avail N	2.1 #/T	1.6 #/T			2.6 #/T			
40#/A	P Rate	13.3 T/A	40 T/A			13.3 T/A			
160#/A	N Rate	80.0 T/A	80 T/A			53.3 T/A			
29/01/2004	TS	127.8 ppt				110.5 ppt			
	TA	25.7 ppt				15.4 ppt			
	TN	3.3 ppt				3.9 ppt			
	P	850 ppm				881 ppm			
	K	847 ppm				494 ppm			
	H2O	87.20%				89.00%			
	pH	6.7				7.9			



	Avail N	2.4 #/T				2.7 #/T			
40#/A	P Rate	80 T/A	40 T/A			10 T/A			
DATE	Results	Raw	MCA Screen		QED Sludge		Grit Chamber		
160#/A	N Rate	10 T/A	80 T/A			53.3 T/A			
20/02/2004	TS	141.6 ppt	210.4 ppt			102.2 ppt			
	TA	20.1 ppt	43.7 ppt			18.2 ppt			
	TN	4.1ppt	2.5 ppt			4.0 ppt			
	P	831 ppm	231 ppm			1,256 ppm			
	K	906 ppm	451 ppm			478 ppm			
	H2O	85.60%	79.00%			90.00%			
	pH	6.5	7.5			7.4			
	Avail N	2.9 #/T	1.7 #/T			2.9 #/T			
40#/A	P Rate	10 T/A	40 T/A			6.6 T/a			
160#/A	N Rate	53.3 T/A	80 T/A			53.3 T/a			
25/03/2004	TS	112.3 ppt	274.5 ppt			123.5 ppt			
	TA	35.6 ppt	131.9 ppt			222.3 ppt			
	TN	3.6 ppt	2.3 ppt			3.9 ppt			
	P	819 ppm	263 ppm			1,169 ppm			
	K	1,412 ppm	522 ppm			621 ppm			
	H2O	88.70%	72.60%			87.70%			
	pH	na	na			na			
	Avail N	2.6 #/T	1.6 #/T			2.7 #/T			
40#/A	P Rate	10 T/A	40 T/A			8.0 T/A			
160#/A	N Rate	53.3 T/A	80 T/A			53.3 T/A			
29/04/2004	Not Sampled								